THE POTENTIALS OF *ACACIA MANGIUM* X *ACACIA AURICULIFORMIS* HYBRID AS AN AFFORESTATION SPECIES FOR IMPOVERISHED SAND TAILINGS

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ABSTRACT

Acacia hybrid has a great potential for fiber production. It can regenerate profusely after fire whereby a mixture of Acacia mangium, Acacia auriculiformis and A. hybrid seedlings dominantly covering the opening of the dead trees after fire. Only the top 10 to 20% of the regeneration achieving the largest size range of 8 cm dbh and 13 m top height at four years after fire and they are all A. hybrid. The total stand volume of the 20 x 30 plot was calculated and estimated the total stand volume of surviving A. hybrid together with their regeneration, and the total stand volume is greater than A, mangium plantation grown at Chikus Forest Reserve which is located 10 km from the study site with same climatic zone. The study shows that Acacia hybrid can be sustainably managed as a fiber crop grown on impoverished sand tailings.

Keyword: *Acacia* hybrid, sand tailings, fiber crop, fast growing plantation

Introduction

Impoverished site such as sand tailings or sandy sites such as Beach Ridges Interspersed with Swales (BRIS) or high composition of sanding soils often require high inputs for growing timber species, consequently it reduces the cost-effectiveness of the industrial forest plantation. The extent of ex-tin mines and BRIS was estimated to be about 360,000 ha in Peninsular Malaysia but due to development for various uses in the past decades, the remaining idle problematic sites to-date were estimated to be about 250,000 ha (Ang & Latif, 2014). Acacias are favourable plantation species for their fast growth rates on impoverished sites, especially *Acacia mangium* x *Acacia auriculiformis* or *A*. hybrid. In addition, easily available planting stocks, free from any known pest and diseases problems, low tending inputs of fertilizers and other tending practices make *A*. hybrid attractive for a large-scale forest plantation development. It has been planted in Southeast Asia. In Vietnam alone, the forest plantation covers 220,000 ha. A demonstration plot of size 20 x 30 m was established on sand tailings in Tin Tailings Afforestation Centre (TTAC), SPF Bidor. The *A*. hybrid seedlings established on sand tailings were from tissue culture materials produced by Forest Research Institute Malaysia. The mean stand height was 13.0±1.6 m with an average stand diameter at breast height (dbh) of 8.1±0.1 cm and the live-crown-ratio of the stand was 85.2±3.2% at four years after planting. The growth data falls within the growth curve of *A*. hybrid grown in good minerals soils. The stand was covered with undergrowth of shrubs and herbaceous plants. The plot was burnt at age of four years old and a study was carried out on its regeneration. The density of regeneration under the dead trees and surviving trees were monitored at seven years and they maintained at estimated 3,500 stems/ha and 8,900 stems/ha, respectively. This finding indicates that the *A*. hybrid could be managed under a sustainable management regime if it is to be grown as a plantation crop on sand tailings. Hence, this paper aims to highlight the potential of *A*. hybrid as a pulpwood species on impoverished sand.

METHODOLOGY

The approach to propose *A*. hybrid for the development of pulpwood plantation species on impoverished sandy site is based on research findings. Based on published documents together with the planting experiences in TTAC, the species potential for fiber plantation development shall be assessed based on the published data and plantation experiences of its planting stock, tending regime, growth and yield data, pulpwood properties, pests and diseases control.

RESULTS AND DISCUSSIONS

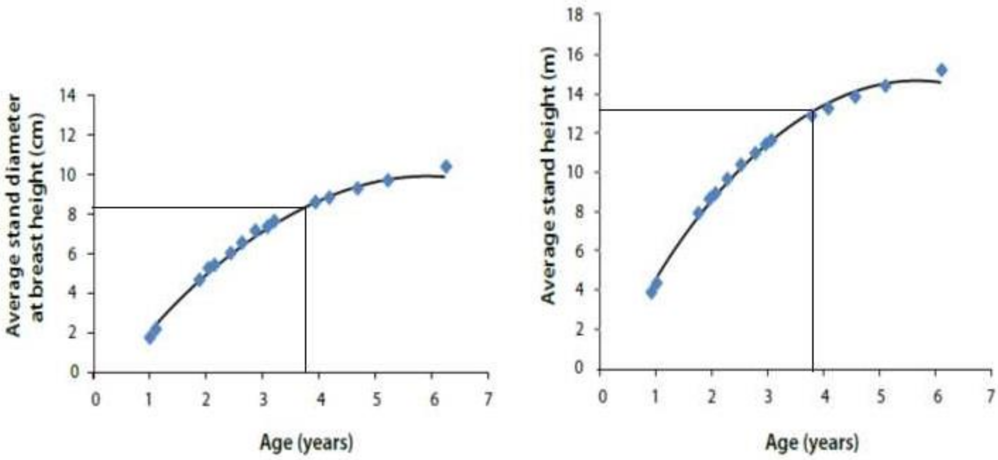
Availability of Planting Stock

This study is based on the experience of planting *A*. hybrid in TTAC using acclimatized tissue culture plantlets. It is also well documented that plantation experiences in Sabah and *A*. hybrid plantation covers 220,000 ha in Vietnam, their planting stock is from clonal materials via tissue culture and cuttings, respectively (Galiana *et al*., 2003; Sein & Mitlohner, 2011). Hence, availability of planting stock for large-scale planting is not a limiting factor.

Estimated Growth and Yield

The data obtained from 4-year-old *A*. hybrid on a 20 x 30 m research plot established on sand tailings is too small to represent survival, growth and yield. Measurement of dbh, top height and live-crown ratio of the stand at four years after planting is plotted in the growth curve obtained for the *A*. hybrid grown on good mineral soils in Vietnam. A growth curve was generated from 89 growth and yield plots in Vietnam. Results from this study showed that stand height and dbh measurements fall within the growth curve indicating comparable growth of *A*. hybrid in TTAC with those of age 3.8 years old in Vietnam (Figure 1).

Figure 1: The mean stand height and diameter at breast height of 4-year-old *Acacia* hybrid stand in Tin Tailings Afforestation Centre is plotted in the growth curves of *Acacia* hybrid grown on good mineral soils in Vietnam



Acacia plantations are prone to fire as they produce thick litter layers comprising leaves, twigs and branches. During the dry period from February to June, the *A.* hybrid stand was burnt accidentally by fire caused by shepherds. Hence, this paper used the data collected from the study on the regeneration of *A.* hybrid after fire under the surviving and dead trees.

Table 1 shows that based on the survival count of regeneration under the living trees of the burnt plot, the regeneration is reduced from 10,000 stems/ha to 3,500 stems/ha from year one to year seven after the fire. For the regeneration under the dead trees, the stem density is higher than those found under the living trees after the fire. The final density count at seven years after the fire is 8,900 stems/ha.

The estimated volume of *A.* hybrid on sand tailings was found to be lesser than the yield of *A. mangium* grown in good mineral soils in the same climatic zone (Table 1). However, together with the trees from the regeneration the estimated total volume of the stand after fire is greater than the *A. mangium* grown on good mineral soils. Other study shows that the parental acacias species have the highest mean annual increment (MAI) in volume of 12 m^3/ha/year but *A.* hybrid achieved 22 m^3/ha/year under similar growing conditions (Bueren, 2004). Hence, *A.* hybrid grown on good mineral soils has a promising potential as a plantation species since it was shown to be more vigorous and adaptable than both parent species (Chia, 1993).

Table 1: Estimated yield of *Acacia* hybrid grown on sand tailings based on the growth curves of *Acacia* hybrid grown at good mineral soils in Vietnam

Year after fire	1	2	3	4	5	6	7
A. Under surviving trees (4-yr-old)	70	38	38	38	38	38	38
1)Stem density/ha	1166	633	633	633	633	633	633
2)Estimated volume(m^3/ha)	122	66.3	82.9	99.5	116.1	132.6	149.3
3)Regeneration density/m^2	1	0.4	0.37	0.36	0.35	0.35	0.35
4)Standard deviation	0.9	0.3	0.29	0.27	0.23	0.23	0.23
5)Estimated density/ha	10,000	4,000	3,700	3,600	3,500	3,500	3,500
6)Standard deviation	9,000	3,000	2,900	2,700	2,300	2,300	2,300
7)Estimated volume (m^3/ha) for 20%	NA	NA	NA	29.5	35.9	43.1	50.3
8)Standard deviation	NA	NA	NA	22.1	23.6	28.3	33.1
B. Under dead trees	45	77	77	77	77	77	77
1)Regeneration density/m^2	2	1.2	1.2	0.99	0.99	0.89	0.89
2)Standard deviation	2.1	1.3	0.3	0.77	0.77	0.63	0.63
3)Estimated density/ha	20,000	12,000	12,000	9,900	9,900	8,900	8,900
4)Standard deviation	21,000	13,000	3,000	7,700	7,700	7,300	7,300
5)Estimated volume (m^3/ha) for 10%	NA	NA	NA	40.67	50.8	54.8	53.9

6)Standard deviation	NA	NA	NA	31.6	39.5	44.9	52.4
C. *Acacia* hybrid							
Estimated total stand volume (m^3/ha)							
(A2+A7+B5)	122	66.3	82.9	169.67	202.8	230.5	253.5
D. *Acacia mangium* *							
Estimated volume(m^3/ha)	96	122.5	145.8	167.3	186	202	214

Note:
i) The estimated stand density was calculated based on per m^2 count of the regeneration under the burnt plot size of 20 x30 m.
ii) + and * denote estimation of volume based on the findings of Sein & Mitloher (2011) and Matsumura (2011), respectively.
iii) 10% and 20% are estimated percentage of trees from the regeneration plot achieving mean diameter of 8 cm and top height of 13 m at four years after fire under the surviving and dead trees, respectively.
iv) NA denotes not available.

The superiority of yield for *A. auriculiformis* x *A. mangium* amongst other forest plantation species is well established (Table 2). Moreover, the estimated yield of *A.* hybrid was grown on sand tailings.

Table 2: Mean annual increment of merchantable volume of some selected timber species

Species	Stand age (y)	VMAI (m^3/ha/yr)	Source
Acacia auriculiformis x Acacia mangium (*Acacia* hybrid)	7	36.2	This study
Acacia mangium	7	35.2	Zuhaidi (2002)
Acacia auriculiformis	4	24.2	NAS (1982)
Tectona grandis	10	16.4	Hashim & Mohd Noor (2002)
Azadirachta excelsa	40	14.4	Zuhaidi & Weinland (1995)
Shorea leprosula	30	10.8	Kollert *et. al*. (1996)
Khaya ivorensis	20	7.5	Lok & Ong (2002)
Hevea brasiliensis	25	2	Najib (2002)

VMAI denotes Mean Annual Increment of Volume (in m^3 per hectare per year)

Tending Regime
Based on the published document on plantation practices of growing *A.* hybrid on good mineral soils, the activities of tending regime include fertilizer regime, pruning frequency, thinning and final harvesting are well documented (Sein & Mitlohner, 2011). Slight modification on the timing of the tending regime may be needed for growing this species on impoverished sand. Pruning is not needed in the stand established in TTAC as the regeneration is self-pruned. No fertilizer was applied as it is not needed due to abundant presence of rhizobium nodules attached to the tertiary roots and feeder roots of *A.* hybrid.

Fiber Quality, Pulp Quality and Mechanical Properties
Acacia hybrid has higher wood density, better mechanical properties and higher cellulose content compared to *A. mangium* and is less prone to heart-rot diseases, which have affected the final recovery rates of *A. mangium* logs (Yamada *et al.* 1990; Wong, 1993). Hence, *A.* hybrid is better than *A. mangium* as plantation species for fiber production.

CONCLUSIONS
Fully aware of the limitation of this study, as the data collected is based on a small demonstration plot, nevertheless it is a practical reality. The *Acacia* hybrid stand in the experimental plot could sustain growth and produce high quantity of regeneration which has estimated 7-year-old stand yield of more than *Acacia mangium* grown on good mineral soils as planting distance of 3 x 3 m in the same climatic zone. In addition, the species is proven to be a better species for pulpwood and it can thrive in infertile sand tailings. The abundant regeneration after fire could be sustainably managed through proper thinning program to produce logs for both pulp and sawn timber production. Hence, this species has great potential to be developed as a forest plantation species and should be recommended for a pilot plantation trial on impoverished sites.

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